

ANNUAL PROGRESS REPORT

Estimation of Juvenile Striped Bass Relative Abundance in the Virginia Portion of Chesapeake Bay

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PREFACE

The primary objective of the Virginia Institute of Marine Science juvenile striped bass survey is to monitor the relative annual recruitment success of juvenile striped bass in the major Virginia nursery areas of lower Chesapeake Bay. The U.S. Fish and Wildlife Service initially funded the survey from 1967 to 1973. After a hiatus ending in 1980, funds were provided by the National Marine Fisheries Service under the Emergency Striped Bass Study program. Commencing with the 1988 annual survey, the work was jointly supported by Wallop-Breaux funds (Sport Fish Restoration Act) administered through the U.S. Fish and Wildlife Service and the Virginia Marine Resources Commission. This report summarizes the results of the 2007 sampling period and compares these results with previous years.

Specific objectives for the 2007 program were to:

1. estimate the relative abundance of the 2007 year class of striped bass from the James, York and Rappahannock river systems,
2. quantify environmental conditions at the time of collection and
3. examine relationships between juvenile striped bass abundance and environmental and biological data.

INTRODUCTION

Historically, the Atlantic striped bass (*Morone saxatilis*) has been one of the most commercially and recreationally sought-after fish species on the east coast of the United States. Decreases in the commercial harvest of striped bass in the 1970s paralleled the steady decline in abundance of striped bass along the east coast; abundance of the Chesapeake Bay stock was particularly depressed. Because the tributaries of Chesapeake Bay had been identified as the primary spawning and nursery area for the migratory portion of the stock, fishery managers made recommendations and eventually enacted regulations intended to halt and reverse the decline of striped bass in Chesapeake Bay and elsewhere along the east coast (ASMFC 2003).

In 1981, the Atlantic States Marine Fisheries Commission (ASMFC) developed the Atlantic Coast Striped Bass Interstate Fisheries Management Plan (FMP), which included recommendations on management measures to improve the status of the stocks. The Virginia Marine Resources Commission adopted this plan in March 1982 (Regulation 450-01-0034), but ASMFC did not have regulatory authority for fisheries management in individual states at that time. As striped bass populations continued to decline, Congress passed the Atlantic Striped Bass Conservation Act (PL 98-613) in 1984, which required states to either follow and enforce management measures in the FMP or face a moratorium on striped bass harvests. Since 1981 the FMP was amended six times to address changes in the management of the stocks. Amendment VI to the plan, adopted in February 2003, requires "producing states" (i.e., Virginia, Maryland, Delaware and New York) to develop and support programs to monitor recruitment.

Well before the FMP requirement, Virginia began monitoring the annual recruitment of juvenile striped bass with funding from the Commercial Fisheries Development Act of 1965 (PL88-309). This monitoring, begun in 1967, continued until 1973. Monitoring of striped bass recruitment was re-instituted in 1980 with Emergency Striped Bass Study funds (PL 96-118, 16 U.S.C. 767g, the "Chafee Amendment"), and since 1989 has been funded by the Wallop-Breaux expansion of the Sport Fish Restoration and Enhancement Act of 1988 (PL 100-448, "the Dingle-Johnson Act").

Initially, the Virginia program used a 6 ft x 100 ft (2 m x 30.5 m) x 0.25 in (6.4 mm) mesh bag seine, but comparison tows with Maryland gear (4 ft x 100 ft x 0.25 in mesh; 1.2 m x 30.5 m x 6.4 mm mesh) showed virtually no statistical differences in catch, and Virginia adopted the "Maryland seine" (Colvocoresses 1984). The gear comparison study aimed to standardize methods thereby allowing baywide examination of recruitment success (Colvocoresses and Austin 1987); this was never realized due to remaining differences in data analysis (MD: arithmetic index, VA: geometric index). A baywide index using a geometric mean weighted by river spawning area was finally developed in 1993 (Austin et al. 1993).

METHODS

Field sampling was conducted during five biweekly sampling periods from July through mid-September of 2007. During each sampling period the seine was hauled at 18 historically sampled sites (index stations) and 21 auxiliary stations along the shores of the James, York and Rappahannock systems (Figure 1). Auxiliary sites were added in 1989 to provide better geographic coverage and increase sample sizes within each river system and to permit monitoring of trends in juvenile abundance within each river system. Such

monitoring was desirable in light of increases in stock size and expansion of the nursery ground.

Collections were made by deploying a 100 ft (30.5 m) long, 4 ft (1.2 m) deep, 0.25 in (6.4 mm) mesh minnow seine perpendicular to the shoreline until either the net was fully extended or a depth of about 4 ft (1.22 m) was encountered, pulling the offshore end down-current and back to the shore. Duplicate hauls were made at each index station during each round, and a single haul was made at each auxiliary station during most rounds. At index stations, all fish taken during the first haul were removed from the net, measured, and held in water-filled buckets until after the second haul, then released. All fish collected were identified and counted; all striped bass were measured; and all individuals or a sub-sample of at least 25 individuals of other species were measured to the nearest mm fork length (or total length if appropriate). Salinity, water temperature and dissolved oxygen concentrations were measured after the first haul using a YSI water quality sampler. Sampling time, tidal stage and weather conditions were recorded at the time of each haul. When two hauls were made, an intervening period of 30 minutes was allowed between hauls and the first sample was processed during this interlude. All fishes captured, except those preserved for life history studies, were returned to the water at the conclusion of sampling.

In this report, comparisons of recruitment indices with prior years are made for the “primary nursery” area only (Colvocoresses 1984) by using data collected from months and areas sampled during all years (index stations). Thus, data from auxiliary stations are not included. Because the frequency distribution of the catch is skewed and approximates a negative binomial distribution (Colvocoresses 1984), a logarithmic

transformation ($\ln(x+1)$) was applied to normalize the data prior to analysis (Sokal and Rohlf 1981). Mean values are back-transformed and scaled up arithmetically ($\times 2.28$) to allow comparison with Maryland data. Thus, a “scaled” index refers to an index that is directly comparable with the indices from Maryland.

Mean catch rates are contrasted by comparing 95% confidence intervals. Reference to "significant" differences between means in this context will be restricted to cases of non-overlapping confidence intervals. Because standard errors are calculated from transformed (logarithmic) values, confidence intervals on the back-transformed and scaled indices are non-symmetrical.

RESULTS

Objective 1: Estimate the relative abundance of the 2007 year class of juvenile striped bass from the James, York and Rappahannock river systems.

In 2007, 1,999 young-of-the-year striped bass were collected from 180 seine hauls at index stations and 523 were collected from 89 hauls at the auxiliary stations (Table 1, Figure 1). The index of relative abundance for the index stations is calculated as the adjusted overall mean catch per seine haul. The estimated index for 2007 is 11.96, which is significantly greater than the historical average index of 7.50 (Table 2, Figure 2). (“Historical” refers to all survey years from 1967 to the present.)

James River System

The 2007 index for the James drainage is 20.41, which is significantly higher than the historical James drainage index of 9.62 (Table 3, Figure 3). The 2007 mainstem James (not including the Chickahominy River) index is 18.48 and is also significantly greater than the historical mainstem James index of 8.86. In 2007, five of six index sites

had higher index averages than their respective historic averages. Both index and auxiliary site collections from J42 upstream reported higher collections in comparison to 2006. Juvenile striped bass were widely distributed in the James River in 2007, with the exception of the most downstream auxiliary station (Table 1). Although no striped bass were collected at sampling site J77 in 2006, which replaced J74 and J78, striped bass were collected in 2007 during Round 3.

The 2007 Chickahominy River index is 24.82, which is significantly higher than the historical Chickahominy index of 11.35 (Table 3). Catches at the Chickahominy River index station C1 were highest in early July (round one) and declined sharply in subsequent weeks (Table 1, Figure 4). This contrasts with the trend in catch at C3 which increased each round and peaked in early September (round 5).

York River System

The 2007 index for the York drainage (6.08) was not statistically greater than the historical York drainage index of 5.83 and was the lowest index value by drainage (Table 3, Figure 3). The watershed index value in 2007 (6.08) was lower than estimates from 2006 (11.40) and 2005 (10.78). All stations in the mainstem York River are auxiliary, and juvenile striped bass were captured at Y15 in late July and early August and at Y28 in all sampling rounds (Table 1). Two of three auxiliary sites on the mainstem of the York River were higher than historic averages. Y21 was only sampled once due to weather and no striped bass were captured on that visit. Catches in the mainstem of the York River also occurred in 2003, 2004, 2005, and 2006 (Austin et al. 2004, Austin et al. 2005, Austin et al. 2006), which was a distinct reversal from 2002 when no striped bass were captured at York River mainstem stations.

The 2007 indices for the Pamunkey (5.24) and the Mattaponi (6.77) rivers were not significantly greater than their respective historical averages (Pamunkey = 6.92, Mattaponi = 5.11, Table 3). Highest catches in the Mattaponi were at M44 and M47, although the pattern of catches at these stations was completely opposite. Catches peaked at M44 in early July (round one) and then declined while catches at M47 peaked in late August. For the Pamunkey River index stations, catches were highly variable and highest catches occurred in early July at P42 and P45 and in late August at P50.

Rappahannock River System

The 2007 index for the Rappahannock River was 14.87, which is statistically greater than the historical average of 7.69 (Table 3). But, while all Rappahannock index stations had individual indices greater than their historic averages, catches at the seven auxiliary sites were either similar to or lower than historic averages. No fishes were collected at the lowermost stations, R10 and R21. And, only two fish were collected at the uppermost sampling site, R75 (Table 1). Catches were greatest at the two uppermost index sites (R50 and R55) with R55 being the most productive site (Table 1, Figure 7). Catches at these two sites accounted for 70% of the total catch for the river in 2007. The greatest numbers of striped bass were captured in early July (round one).

Sampling Round Comparison

Generally, raw catch values are highest during July and early August (rounds one, two, and three) and taper off in late August and September (rounds four and five) as fish disperse to deeper water and grow large enough to effectively avoid capture. In 2007, our catches were greatest in early July (round one) (Table 4). Catches in late July (round

two) decreased by 36%, and catches in early August (round three) decreased by 26% relative to late July. A slight increase of 8% was observed in late August (round four), but this was followed by a 7% decrease in early September (round five).

Objective 2: Quantify environmental conditions at the time of collection.

Collection information and pertinent environmental variables recorded at the time of each collection in 2007 are given in Tables 5 through 7. Direct round-by-round comparisons of environmental and water quality parameters are difficult because of local site conditions and variations, so we examined this on a broader scale.

Striped bass recruitment is correlated with temperature and rainfall trends for the winter and spring preceding sampling (Wood 2000), and their distribution within the nursery may be affected by water quality parameters during sampling. Generally, salinities in early 2007 were greater than average (Table 5). Data from the National Climate Data Center (<http://www.ncdc.noaa.gov/oa/ncdc.html>) indicated that both winter (December 2006 through February 2007) and spring (March through May 2007) were characterized by below average precipitation. After average rainfall in June, the amount of precipitation in Virginia remained below average in July, August and September and salinities were above average during this time.

The normal pattern of high temperatures in the mid summer and slowly declining temperatures during the late summer was well defined in 2007 as in other years (Table 6). Temperatures were slightly elevated during Round 5 in relation to temperatures in 2006. Water temperatures in these systems reflect the long-term weather patterns of summer, but also exhibit significant day-to-day and river-to-river variation. Sampling takes place at shallow shoreline areas that are easily affected by local events such as thunderstorms

and by small-scale spatial and temporal variations associated with time of sampling (e.g. morning versus afternoon or tidal stage). The effects of these events on site-specific striped bass abundances are not easily assessed.

None of the dissolved oxygen (DO) levels measured during the survey in 2007 are considered hypoxic (less than 2-3 mg/L; Table 7). The mean dissolved oxygen level was 6.2 mg/L but ranged from 3.9 to 12.1 mg/L.

Objective 3: Examine relationships between juvenile striped bass abundance and environmental and biological data.

In 2007, as in the past, we observed greater catches of young-of-the-year striped bass at lower salinities within the primary nursery area (Table 8). No index station exceeded 14.2 ppt salinity (Table 5). Table 9 shows the relationship of juvenile striped bass catches with respect to historical and 2006 salinity gradients within each river system. In 2007, the percentage of catch observed in low salinities (0-4 ppt) was the same as that observed historically (92% in 2007 vs. 93% all years) (Table 8). Juvenile striped bass were captured at downstream auxiliary sites in the early rounds of the 2007 survey in areas with salinities greater than 8.6 ppt. Salinity is not the only factor accounting for the distribution of striped bass in 2007.

Catch rates in 2007 followed the historical pattern with respect to water temperature: most fish (99.5%) were captured in waters between 25 and 34.9 °C (Table 10). As noted in previous reports, this relationship is considered to be largely the result of a coincident downward progression of both catch rates and temperature as the survey season progresses (beyond early August) rather than any direct effect of water temperature on juvenile fish distribution.

Dissolved oxygen measured at the time of sampling does not seem to have a direct effect on indices. Dissolved oxygen concentrations lower than the mean at a station (Table 7) do not necessarily correspond with low catches at that station (Table 1).

DISCUSSION

Striped bass recruitment success in the Virginia portion of Chesapeake Bay is variable among years and among nursery areas within years. Striped bass from the three watersheds exhibited greater than average recruitment in 2007 with young-of-the-year fish evenly distributed throughout the primary nursery area. The size of the nursery area was generally similar to that of 2006. Striped bass young-of-the-year abundance was low in 1999 and 2002, but strong year classes were observed in 1998, 2000, 2001, 2003 and 2004. This was followed by average recruitment in 2005 and above average catches in both 2006 and 2007. Continued monitoring of recruitment success will be an important factor in determining management strategies to protect the spawning stock of Chesapeake Bay striped bass.

The James River system had the highest index value and served to bolster the overall index value for the Virginia portion of the Chesapeake Bay. In 2006, J77 replaced J74 and J78 which could no longer be seined, but no striped bass were captured during collections. The first reported catch of striped bass in J77, in 2007 suggests young-of-year striped bass may use this site. Further sampling should validate the ability of J77 to document continued use of upstream habitat by juvenile striped bass.

Similarly, collections of juvenile striped bass at R75 during Round 5 suggest that this site is a new suitable auxiliary station for striped bass. No fishes were collected at the lowermost stations, R10 and R21 (Table 1). Few fish were collected at these sites in 2006

or 2005 (Austin et al. 2006, Hewitt et al. 2007). No striped bass were captured at auxiliary sites R10 and R21, but this observation may simply reflect interannual variation. Further sampling in 2008 may provide additional information on the use of these auxiliary sites by striped bass.

The 1989 addition of auxiliary stations to the survey has provided better overall coverage of nursery areas in the James, York and Rappahannock systems. Catches at auxiliary stations reveal annual shifts in the spatial distribution of young-of-year fish. During years of low or high river flow, nursery areas shift up- or down-river. Additionally, in years of high abundance nursery areas generally expand both up- and down-river.

Although catch data from the auxiliary sites are not used to compute the index, these data can be used to examine shifts in the spatial distribution of nursery areas. Such shifts may partially explain variation in catch rates at the index sites. Catches at index sites are consistently greater in the first haul than in the second seine haul. Because only one haul is made at the auxiliary sites, figures 4-7 may over-emphasize the contribution of the auxiliary sites relative to the index sites; however, the figures are included here to demonstrate the spatial distribution of the year class in the river systems. Reducing hauls at index sites to one per site and including some of the auxiliary sites in the index may lead to a more precise estimate of relative year-class strength but would elevate the recalculated indices (Rago et al. 1996).

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Table 1. Catch of young-of-the-year striped bass per seine haul in 2007. Two hauls were made per sampling round at each of the index stations (bold).

Drainage																	
JAMES	Station	J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J77	Round Total		
	Round	1	0	42	0/1	11/4	23	50/24	31/0	43/65	41	16/11	44	18	0	424	
		2	0	40	8/0	9/1	9	3/19	23/9	61/11	13	10/29	24	15	0	284	
		3	0	2	4/0	8/0	12	16/14	29/12	47/41	3	16/5	6	1	4	220	
		4	0	0	3/6	16/10	2	7/1	25/3	30/35	2	10/6	12	3	0	171	
		5	0	35	3/1	22/11	1	10/5	73/4	12/3	7	12/11	0	33	0	243	
														James Total	1342		
YORK	Station	Y15	Y21	Y28	P36	P42	P45	P50	P55								
	Round	1	ns	ns	7	19	6/8	12/3	17/1	10						83	
		2	14	ns	4	2	13/1	6/2	26/4	ns						72	
		3	3	0	5	4	2/3	1/0	0/1	ns						19	
		4	0	ns	8	3	2/1	1/0	54/0	1						70	
		5	0	ns	1	ns	0/1	2/1	0/0	ns						5	
	Station				M33	M37	M41	M44	M47	M52							
	Round	1				9/5	7	0/1	84/28	0/3	ns						137
		2				5/1	1	0/0	10/21	5/7	ns						50
		3				0/1	0	0/0	14/3	9/5	5						37
		4				0/0	ns	3/1	12/8	16/5	0						45
		5				0/0	0	2/3	8/1	8/3	0						25
														York Total	543		
RAPPAHANNOCK	Station	R10	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R75				
	Round	1	0	0	5/5	5/9	1	18/18	8/12	59/74	0	1	10	0	225		
		2	ns	0	1/1	2/3	0	24/14	10/9	52/11	2	ns	4	0	133		
		3	0	0	2/2	0/6	1	5/2	6/6	28/17	0	0	2	ns	77		
		4	0	0	2/1	4/3	11	2/6	9/10	25/13	0	0	0	0	86		
		5	0	ns	4/1	3/0	2	7/0	44/35	11/6	0	1	0	2	116		
														Rappahannock Total	637		
ns = no sample												2007 Catch		2522			

Table 2. Catch of young-of-the-year striped bass per seine haul in the primary nursery area (index stations) summarized by year (scaled mean = back-transformed mean of $\ln(x+1) * 2.28$, the ratio of overall arithmetic and geometric means through 1984).

Year	Total Fish	Mean $\ln(x+1)$	Std. Dev.	Scaled Mean	C.I. (± 2 SE)	N (hauls)
1967	209	1.07	0.977	4.40	2.82-6.45	53
1968	208	0.93	0.900	3.50	2.35-4.94	66
1969	207	0.78	0.890	2.71	1.80-3.84	77
1970	461	1.31	1.121	6.17	4.27-8.63	78
1971	178	0.76	0.857	2.61	1.76-3.64	81
1972	96	0.39	0.575	1.07	0.73-1.45	119
1973	139	0.53	0.790	1.59	0.98-2.32	87
1980	228	0.74	0.900	2.52	1.68-3.53	89
1981	165	0.52	0.691	1.57	1.10-2.09	116
1982	323	0.78	0.967	2.71	1.85-3.74	106
1983	296	0.91	0.833	3.40	2.53-4.42	102
1984	597	1.09	1.059	4.47	3.22-6.02	106
1985	322	0.72	0.859	2.41	1.78-3.14	142
1986	669	1.12	1.036	4.74	3.62-6.06	144
1987	2191	2.07	1.228	15.74	12.4-19.8	144
1988	1348	1.47	1.127	7.64	6.10-9.45	180
1989	1978	1.78	1.119	11.23	9.15-13.7	180
1990	1249	1.44	1.096	7.34	5.89-9.05	180
1991	667	0.97	0.951	3.76	2.96-4.68	180
1992	1769	1.44	1.247	7.32	5.69-9.28	180
1993	2323	2.19	0.975	18.12	15.4-21.3	180
1994	1510	1.72	1.034	10.48	8.66-12.6	180
1995	926	1.22	1.045	5.45	4.33-6.75	180
1996	3759	2.41	1.227	23.00	18.8-28.1	180
1997	1484	1.63	1.097	9.35	7.59-11.4	180
1998	2084	1.92	1.139	13.25	10.8-16.1	180
1999	442	0.80	0.862	2.80	2.19-3.50	180
2000	2741	2.09	1.240	16.18	13.06-19.92	180
2001	2624	1.98	1.271	14.17	11.33-17.60	180
2002	813	1.01	1.085	3.98	3.05-5.08	180
2003	3406	2.40	1.18	22.89	18.84-27.71	180
2004	1928	1.88	1.04	12.70	10.54-15.22	180
2005	1352	1.61	1.05	9.09	7.45-11.02	180
2006	1408	1.69	1.04	10.10	8.31-12.18	180
2007	1999	1.83	1.18	11.96	9.66-14.70	180
Overall (1967-2007)	42101	1.46	1.19	7.50	7.18-7.83	5109

Table 3. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 2007 summarized by drainage and river.

Drainage River	<u>2007</u>				<u>All Years Combined</u> (1967-2007)			
	Total Fish	Scaled Mean	C.I. (± 2 SE)	N (hauls)	Total Fish	Scaled Mean	C.I. (± 2 SE)	N (hauls)
JAMES	950	20.41	14.65-28.11	60	16752	9.62	8.95-10.34	1698
James	592	18.48	12.12-27.65	40	9972	8.86	8.11-9.66	1140
Chickahominy	358	24.82	14.38-41.81	20	6780	11.35	9.99-12.87	558
YORK	449	6.08	4.13-8.62	70	12238	5.83	5.44-6.25	1942
Pamunkey	168	5.24	2.80-8.86	30	6354	6.92	6.20-7.71	826
Mattaponi	281	6.77	4.02-10.71	40	5884	5.11	4.67-5.58	1116
RAPPAHANNOCK	600	14.87	10.45-20.84	50	13111	7.69	7.06-8.36	1469
OVERALL	1999	11.96	9.66-14.70	180	42101	7.50	7.18-7.83	5109

Table 4. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 2007 summarized by sampling period and month.

Month (Round)	<u>2007</u>				<u>All Years Combined (1967-2007)</u>			
	Total Fish	Scaled Mean	C.I. (± 2 SE)	N (hauls)	Total Fish	Scaled Mean	C.I. (± 2 SE)	N (hauls)
July (1 st)	646	19.41	11.87-30.97	36	12801	11.19	10.20-12.26	1070
(2 nd)	411	14.36	9.25-21.73	36	10087	8.56	7.78-9.39	1081
Aug. (3 rd)	305	8.98	5.29-14.46	36	7497	6.82	6.21-7.47	1073
(4 th)	330	11.11	7.04-16.95	36	6843	6.68	6.03-7.38	937
Sept. (5 th)	307	8.47	5.02-13.55	36	4668	5.77	5.18-6.41	811

Table 5. Salinity (parts per thousand) at seine survey stations in 2007. York system includes Pamunkey and Mattaponi rivers. Index stations are indicated by bold font.

Drainage														
JAMES	Station	J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J77*
Round	1	16.7	8.6	3.8	1.4	0.6	0.6	0.5	0.1	0.1	0.1	0.2	0.1	0.1
	2	19.2	10.6	6.1	2.8	1.4	1.5	1.2	0.1	0.2	0.1	0.2	0.1	0.1
	3	19.0	10.9	7.2	4.4	1.8	2.6	2.2	0.6	0.3	0.2	0.2	0.2	0.2
	4	19.2	10.9	7.9	4.5	2.3	3.3	2.9	0.9	0.6	0.3	0.2	0.2	0.2
	5	19.5	12.4	8.8	5.0	2.4	3.0	2.5	0.3	0.4	0.2	0.2	0.2	0.2
YORK	Station	Y15	Y21	Y28	P36	P42	P45	P50	P55					
Round	1	ns	ns	11.4	4.5	1.4	0.4	0.1	0.1					
	2	20.4	ns	12.7	6.3	2.4	0.8	0.2	ns					
	3	20.5	17.8	14.6	6.9	3.3	0.9	0.3	ns					
	4	20.7	ns	14.0	7.0	3.5	1.4	0.5	0.3					
	5	21.0	ns	14.9	ns	3.3	0.9	0.6	ns					
Round	Station				M33	M37	M41	M44	M47	M52				
	1				5.6	3.9	1.4	0.2	0.2	ns				
	2				7.3	5.1	2.6	0.5	0.3	ns				
	3				7.9	5.9	2.8	0.7	0.5	0.1				
	4				10.1	ns	3.3	1.1	0.8	0.1				
	5				8.7	5.8	3.0	1.2	1.3	0.3				
RAPPAHANNOCK	Station	R10	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R75*	
Round	1	14.6	13.6	11.4	6.4	3.2	2.0	0.6	0.2	0.1	0.1	0.1	0.1	
	2	ns	15.7	13.9	8.4	5.6	3.4	1.2	0.6	0.2	ns	0.1	0.1	
	3	17.3	15.2	12.8	8.3	5.2	4.0	2.2	1.3	0.5	0.2	0.1	ns	
	4	17.4	16.2	14.1	9.0	6.4	4.8	2.9	1.8	0.8	0.4	0.1	0.1	
	5	19.4	ns	14.2	8.8	5.7	5.0	3.1	3.5	0.6	0.3	0.1	0.1	

ns = no sample taken; *new station in 2006

Table 6. Water temperature (°C) recorded at seine survey stations in 2007. York system includes Pamunkey and Mattaponi rivers. Index stations are indicated by bold font.

Drainage		Station	J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J77*
JAMES	Round	1	28.8	29.5	30.5	25.0	28.0	26.2	26.5	30.1	27.2	27.0	28.7	29.7	28.9
		2	25.8	26.9	32.5	27.6	32.4	30.7	30.0	29.9	28.0	28.0	27.7	30.6	29.8
		3	31.5	31.8	30.2	27.0	29.7	29.3	29.1	30.5	28.5	28.9	29.0	31.5	29.7
		4	27.6	28.3	29.7	26.6	29.0	28.0	28.6	29.6	29.0	28.5	27.4	31.1	30.4
		5	27.3	28.4	29.2	26.8	28.4	28.1	28.3	28.9	28.0	27.6	29.3	30.5	29.4
YORK	Round	Station	Y15	Y21	Y28	P36	P42	P45	P50	P55					
		1	ns	ns	30.2	29.8	30.1	30.1	29.9	31.1					
		2	27.1	ns	27.1	28.3	28.1	28.8	28.6	ns					
		3	34.7	36.0	32.1	30.8	31.6	31.1	31.3	ns					
		4	26.7	ns	26.6	28.1	27.5	28.2	28.0	27.8					
		5	29.7	ns	30.2	ns	28.9	28.4	28.4	ns					
	Round	Station				M33	M37	M41	M44	M47	M52				
		1				29.6	29.4	29.1	30.2	30.6	ns				
		2				27.9	27.6	25.7	28.0	28.7	ns				
		3				30.5	30.4	30.2	31.1	31.7	33.9				
		4				27.9	ns	27.8	27.8	28.3	28.8				
		5				28.1	28.1	27.8	28.3	30.1	28.2				
RAPPAHANNOCK	Round	Station	R10	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R75*	
		1	27.5	26.6	24.4	25.1	26.2	25.9	27.0	27.5	27.4	28.4	28.4	29.1	
		2	ns	25.6	27.3	27.4	27.3	27.1	28.0	28.4	28.5	ns	29.5	29.9	
		3	27.7	28.2	28.8	29.8	31.5	31.2	28.5	29.4	28.7	30.3	29.4	ns	
		4	30.3	29.3	27.0	27.8	29.4	28.9	28.9	29.3	29.3	31.1	30.1	30.4	
		5	26.3	ns	27.8	28.3	28.9	29.9	27.9	28.0	28.3	28.4	28.6	28.7	

ns = no sample taken, *= new station in 2006

Table 7. Dissolved oxygen concentrations (mg/L) at seine survey stations in 2007. York system includes Pamunkey and Mattaponi rivers. Index stations are indicated by bold font.

Drainage															
JAMES	Station	J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J77*	
Round	1	5.5	6.2	8.3	8.5	7.6	8.1	7.2	8.5	6.0	8.2	12.1	6.2	6.5	
	2	5.1	5.8	6.1	6.1	7.3	7.4	5.8	5.9	5.2	7.6	7.8	7.6	5.5	
	3	5.2	5.5	6.5	5.3	6.1	5.5	5.2	4.8	4.7	7.0	7.0	5.5	5.5	
	4	5.5	6.8	6.3	6.2	6.0	6.8	5.6	5.1	5.0	6.7	7.5	5.8	5.6	
	5	6.0	6.7	6.9	5.1	7.1	5.6	5.5	4.3	4.9	6.2	8.7	5.4	5.7	
YORK	Station	Y15	Y21	Y28	P36	P42	P45	P50	P55						
Round	1	ns	ns	5.3	6.3	6.0	5.7	5.8	6.1						
	2	6.1	ns	5.6	4.6	5.0	5.4	6.8	ns						
	3	7.8	7.5	5.9	5.7	6.0	5.7	5.3	ns						
	4	ns	ns	5.1	4.6	5.5	5.3	4.5	6.2						
	5	7.9	ns	7.0	ns	5.9	5.5	5.8	ns						
Round	Station				M33	M37	M41	M44	M47	M52					
	1				5.1	5.4	5.0	5.8	6.3	ns					
	2				5.0	5.3	8.5	5.0	4.9	ns					
	3				4.2	4.1	5.1	5.1	5.7	5.7					
	4				3.9	ns	4.2	5.0	5.3	6.1					
	5				6.1	5.7	5.4	5.9	6.4	6.5					
RAPPAHANNOCK	Station	R10	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R75*		
Round	1	8.0	7.4	7.0	7.2	7.8	7.4	6.6	6.1	5.8	7.8	7.0	6.8		
	2	ns	5.0	6.2	7.3	6.1	7.1	6.4	6.1	5.8	ns	6.3	6.3		
	3	3.9	4.3	6.5	6.4	7.0	6.9	6.5	6.6	5.6	6.6	6.0	ns		
	4	7.0	5.3	5.6	5.6	6.8	6.4	6.4	7.4	7.0	7.5	6.8	7.1		
	5	6.5	ns	6.9	7.4	7.9	7.4	5.8	5.9	5.8	6.5	6.2	5.8		

ns = no sample taken, *= new station in 2006

Table 8. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 2007 summarized by salinity.

Salinity (ppt)	<u>2007</u>				<u>All Years Combined</u> (1967-2007)			
	Total Fish	Scaled Mean	C.I. (± 2 SE)	N (sites)	Total Fish	Scaled Mean	C.I. (± 2 SE)	N (sites)
0-4.9	1848	15.24	12.0-19.23	137	39041	8.62	8.22-9.02	4268
5-9.9	127	5.75	3.51-8.87	31	2735	4.20	3.69-4.76	611
10-14.9	24	3.55	1.845.97	12	323	1.91	1.49-2.38	201
15-19.9	0	0	0	0	2	0.11	0-0.28	29
Overall	1999	11.96	9.66-14.70	180	42101	7.50	7.18-7.83	5109

Table 9. Average salinity (Avg. Sal., ppt) and corresponding striped bass indices recorded at seine survey stations from 1967 to 2007 and in 2007. York system includes Pamunkey and Mattaponi rivers. Index stations are indicated by bold font.

Drainage														
JAMES	Station	J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J77*
1967-2007	Avg. Sal.	14.0	7.4	4.5	2.4	1.4	1.3	1.2	0.5	0.3	0.2	0.2	0.1	0.1
	Index	2.5	15.4	7.0	12.4	7.9	15.3	7.5	17.8	14.3	5.8	8.2	5.6	0.5
2007	Avg. Sal.	18.7	10.7	6.8	3.6	1.7	2.2	1.9	0.4	0.3	0.2	0.2	0.2	0.2
	Index	0	23.7	3.9	14.8	14.0	22.9	26.8	60.6	18.1	25.9	20.6	19.7	0.9
YORK	Station	Y15	Y21	Y28	P36	P42	P45	P50	P55					
1967-2007	Avg. Sal.	16.3	13.3	10.3	3.8	1.6	0.7	0.4	0.3					
	Index	1.1	1.8	5.0	10.4	3.8	9.5	12.4	6.1					
2007	Avg. Sal.	20.7	17.8	13.5	6.2	2.8	0.9	0.3	0.2					
	Index	4.1	0	9.9	11.1	5.6	4.0	6.3	8.4					
1967-2007	Station				M33	M37	M41	M44	M47	M52				
	Avg. Sal.				4.2	2.2	1.1	0.4	0.3	0.1				
2007	Index				6.1	7.6	6.6	4.4	4.2	1.4				
	Avg. Sal.				7.9	5.2	2.6	0.7	0.6	0.2				
	Index				2.4	2.3	1.6	25.6	10.9	1.9				
RAPPAHANNOCK	Station	R10	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R75*	
1967-2007	Avg. Sal.	14.1	12.8	9.9	5.3	3.2	2.0	1.0	0.6	0.2	0.2	0.1	0.1	
	Index	0.4	0.9	2.4	3.6	4.5	8.5	11.5	38.3	6.7	4.1	3.2	0.4	
2007	Avg. Sal.	17.2	15.2	13.3	8.2	5.2	3.8	2.0	1.5	0.4	0.3	0.1	0.1	
	Index	0	0	4.8	6.0	3.9	14.3	26.8	50.7	0.6	0.9	4.1	0.7	

ns = no sample taken, *= new station in 2006

Table 10. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 2007 summarized by water temperature.

Temp. (°C)	<u>2007</u>				<u>All Years Combined</u> (1967-2007)			
	Total Fish	Scaled Mean	C.I. (± 2 SE)	N (sites)	Total Fish	Scaled Mean	C.I. (± 2 SE)	N (sites)
15-19.9	0	0	0	0	79	2.85	1.40-4.86	30
20-24.9	10	11.40	11.40-11.40	2	2560	3.63	3.18-4.11	659
25-29.9	1525	12.68	10.03-15.91	138	32280	8.45	8.04-8.89	3603
30-34.9	464	9.73	5.63-15.97	40	6792	8.78	7.83-9.83	718
Overall	1999	11.96	9.66-14.70	180	42101	7.50	7.18-7.83	5109

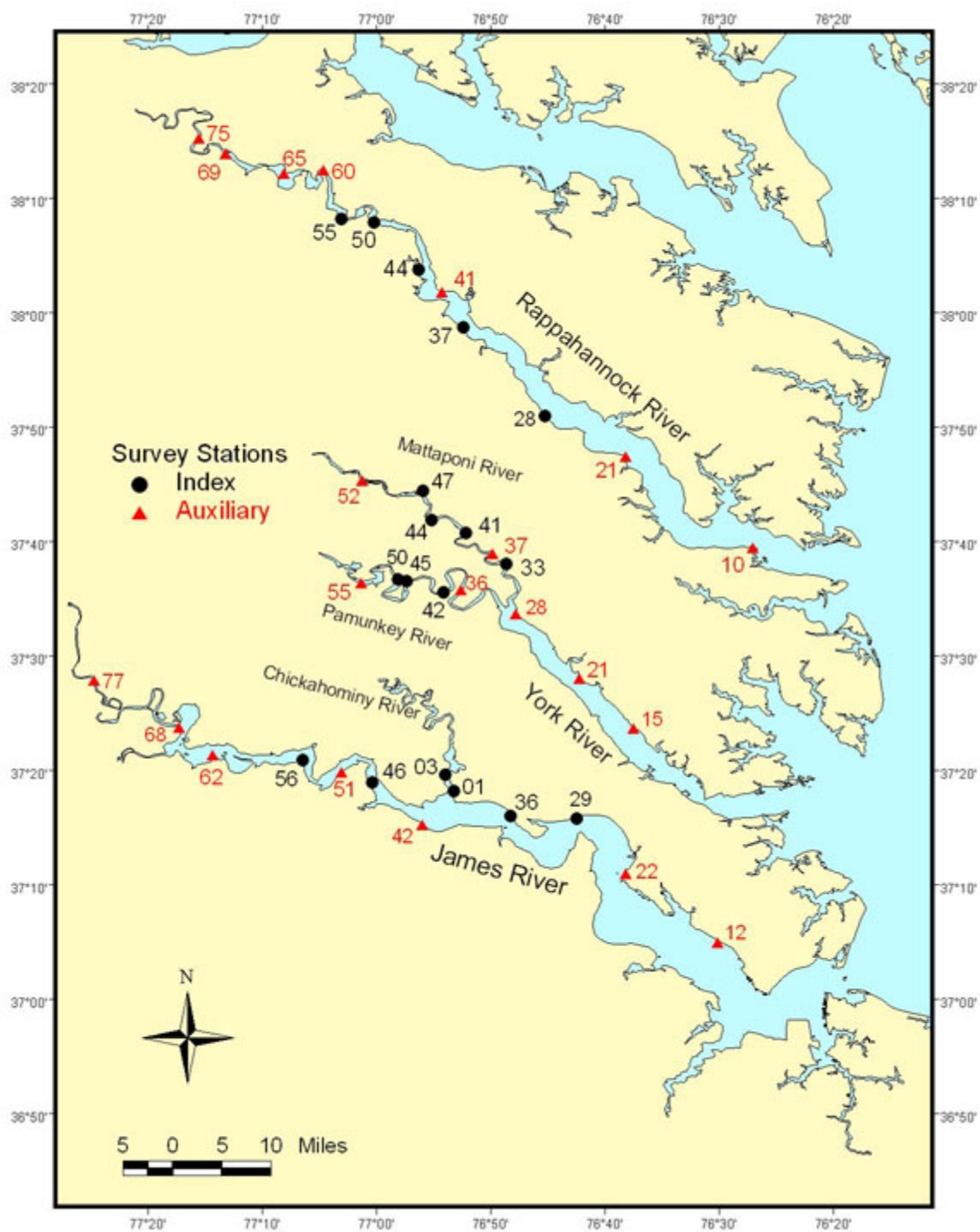


Figure 1. Juvenile striped bass seine survey stations. Numeric portion of station designations indicates river mile from mouth. Auxiliary stations R75 (Rappahannock) and J77 (James) are new in 2006, replacing R76 and J74/J78, respectively.

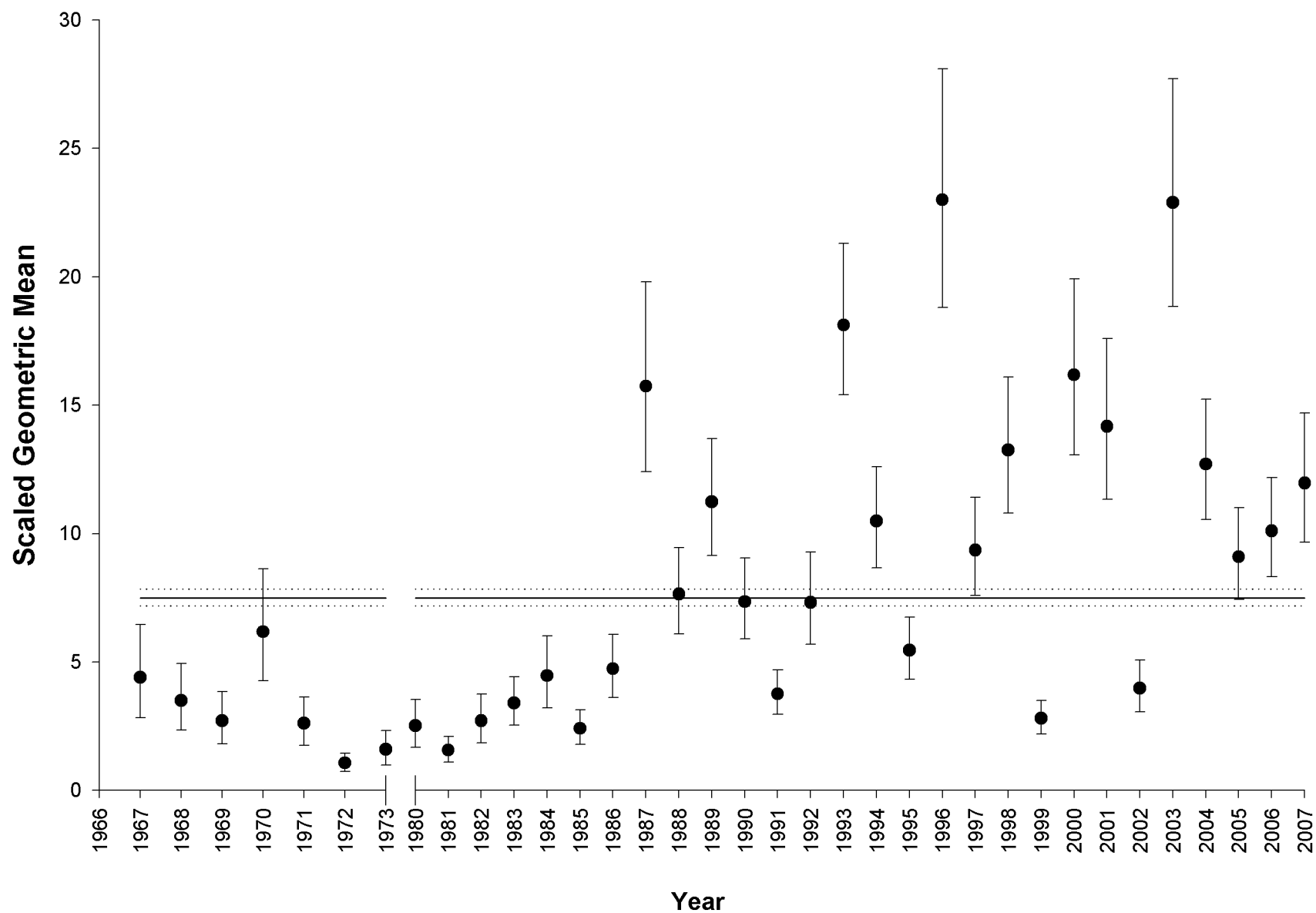


Figure 2. Scaled geometric mean of young-of-the-year striped bass per seine haul in the primary nursery area (index stations) by year. Vertical bars are 95% confidence intervals as estimated by ± 2 standard errors of the mean. Horizontal lines indicate historical geometric mean (solid) and confidence intervals (dotted) for 1967-2007.

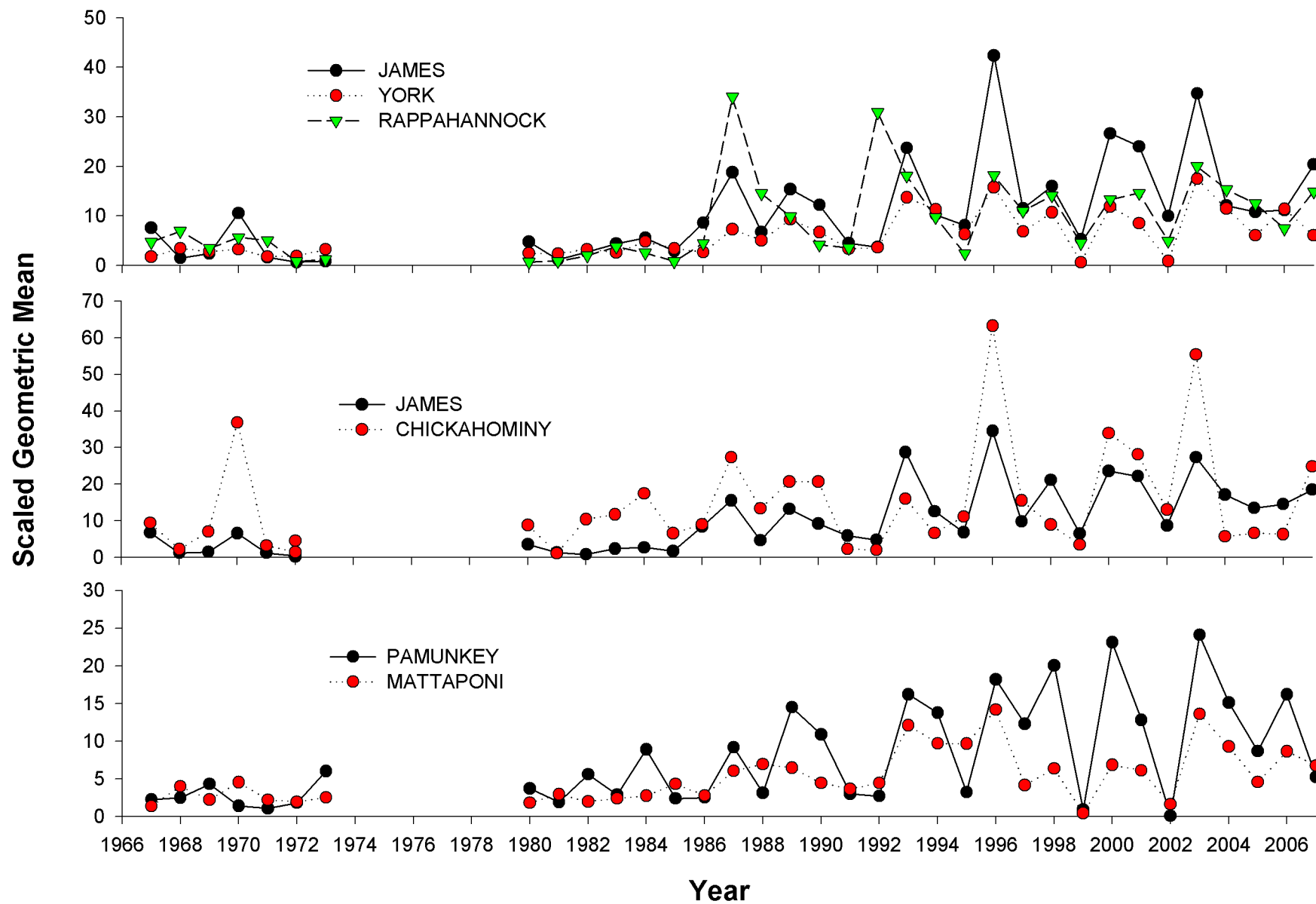


Figure 3. Scaled geometric mean of young-of-the-year striped bass per seine haul in the primary nursery area by drainage and river.

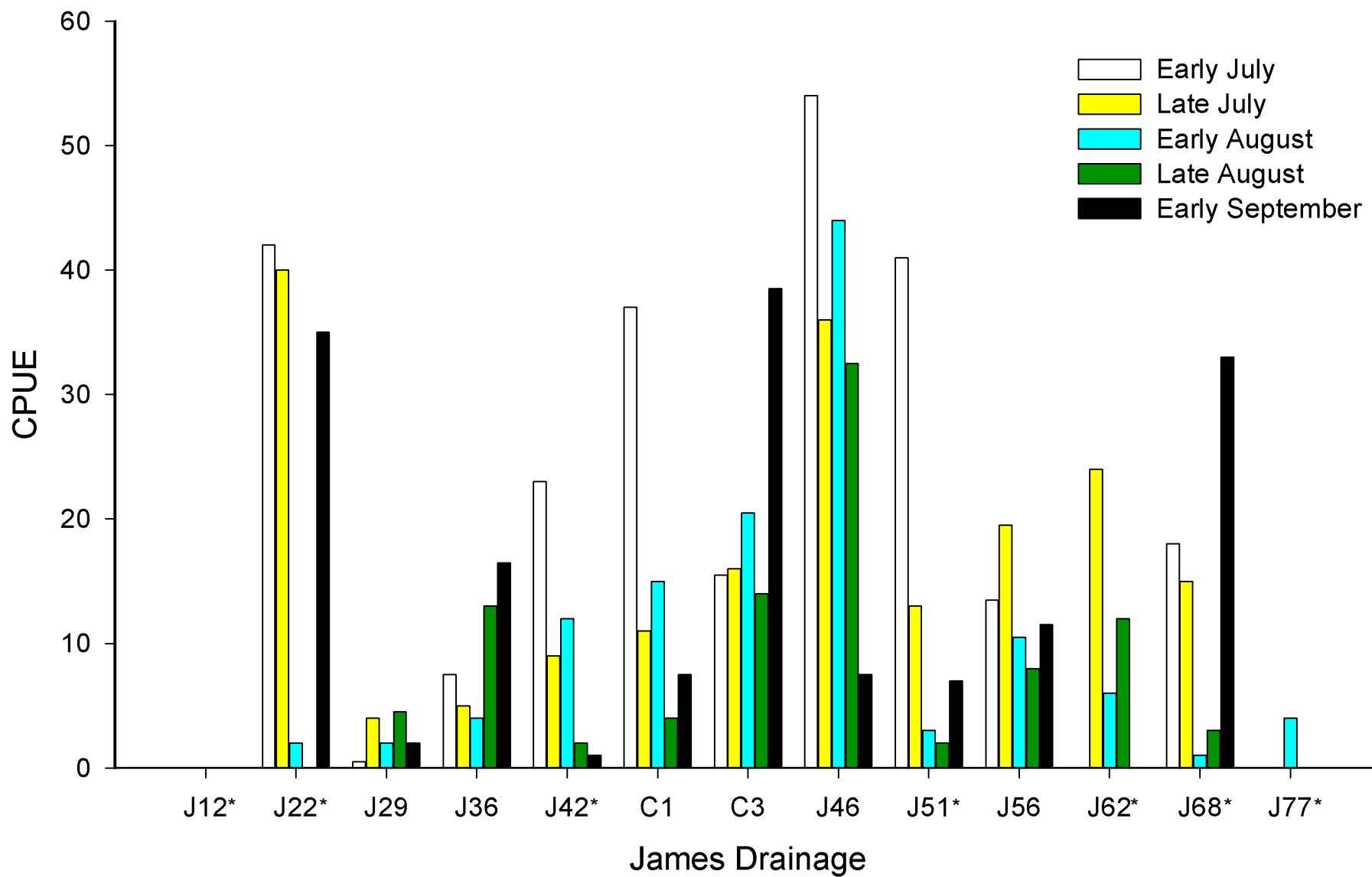


Figure 4. Catch of young-of-the-year striped bass by station in the James River drainage in 2007. Catch at index stations (non-starred) is an average of two hauls. Auxiliary station (starred) catch represents one haul.

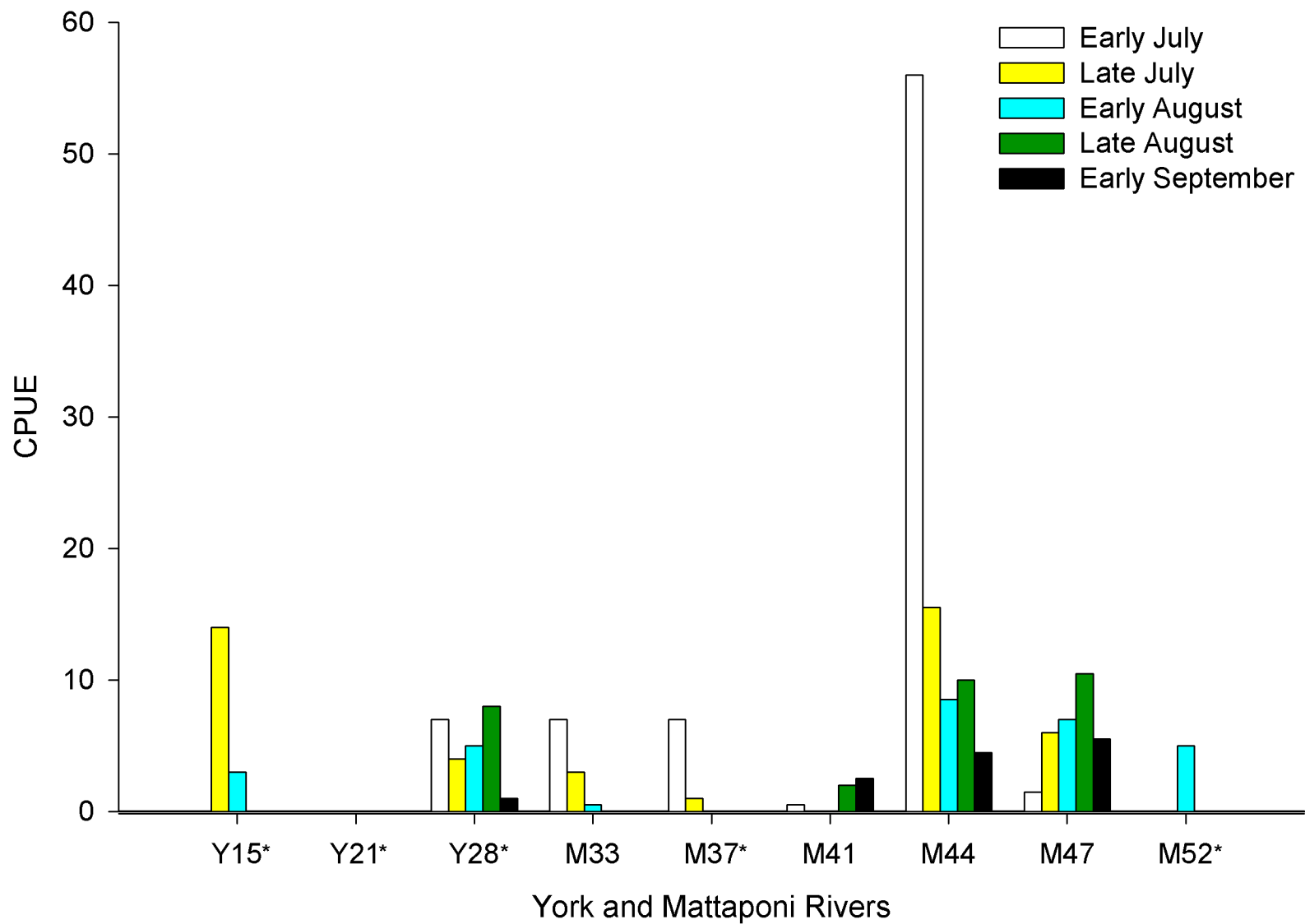


Figure 5. Catch of young-of-the-year striped bass by station in the York and Mattaponi rivers in 2007. Catch at index stations (non-starred) is an average of two hauls. Auxiliary station (starred) catch represents one haul.

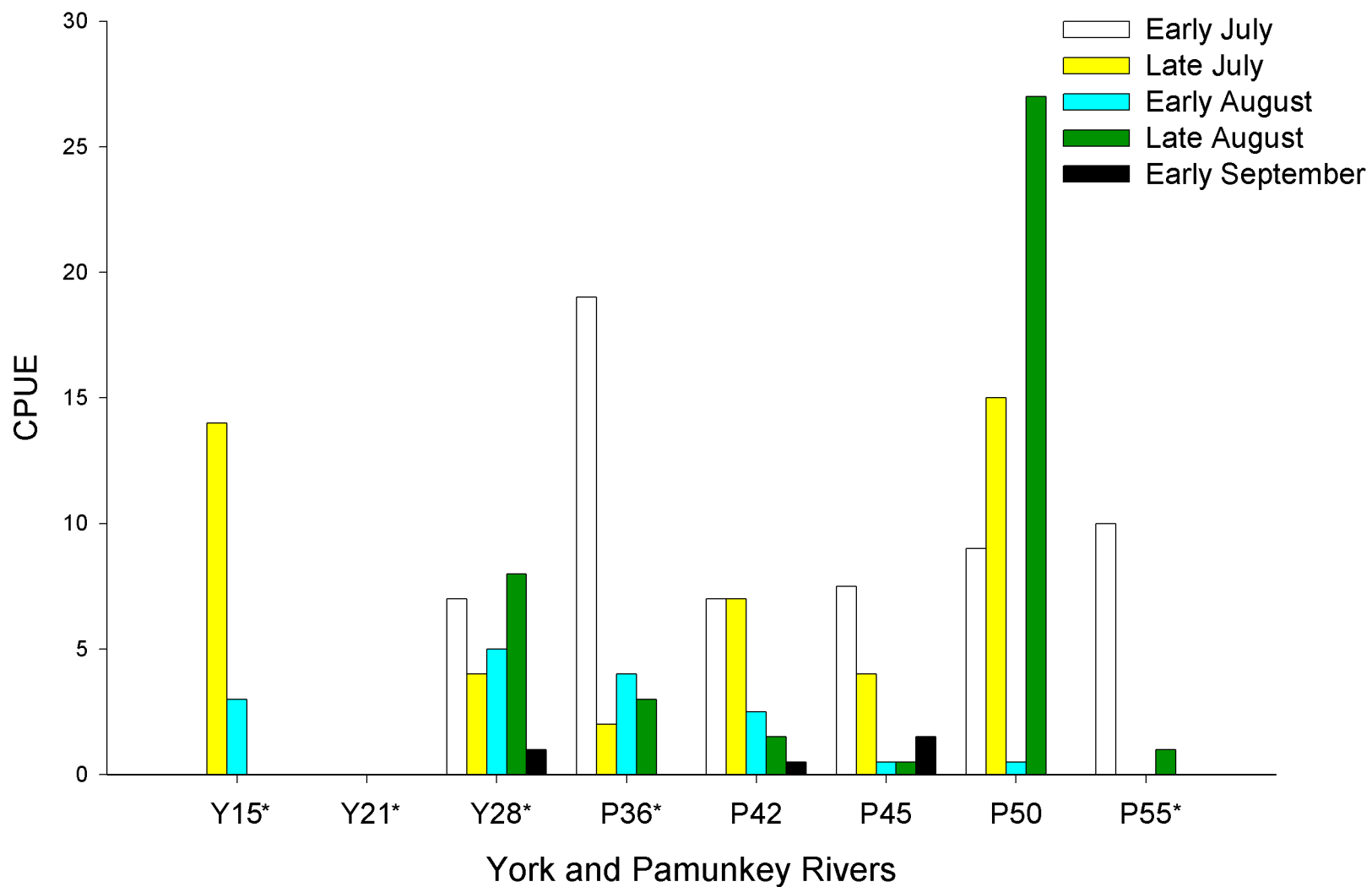


Figure 6. Catch of young-of-the-year striped bass by station in the York and Pamunkey rivers in 2006. Catch at index stations (non-starred) is an average of two hauls. Auxiliary station (starred) catch represents one haul.

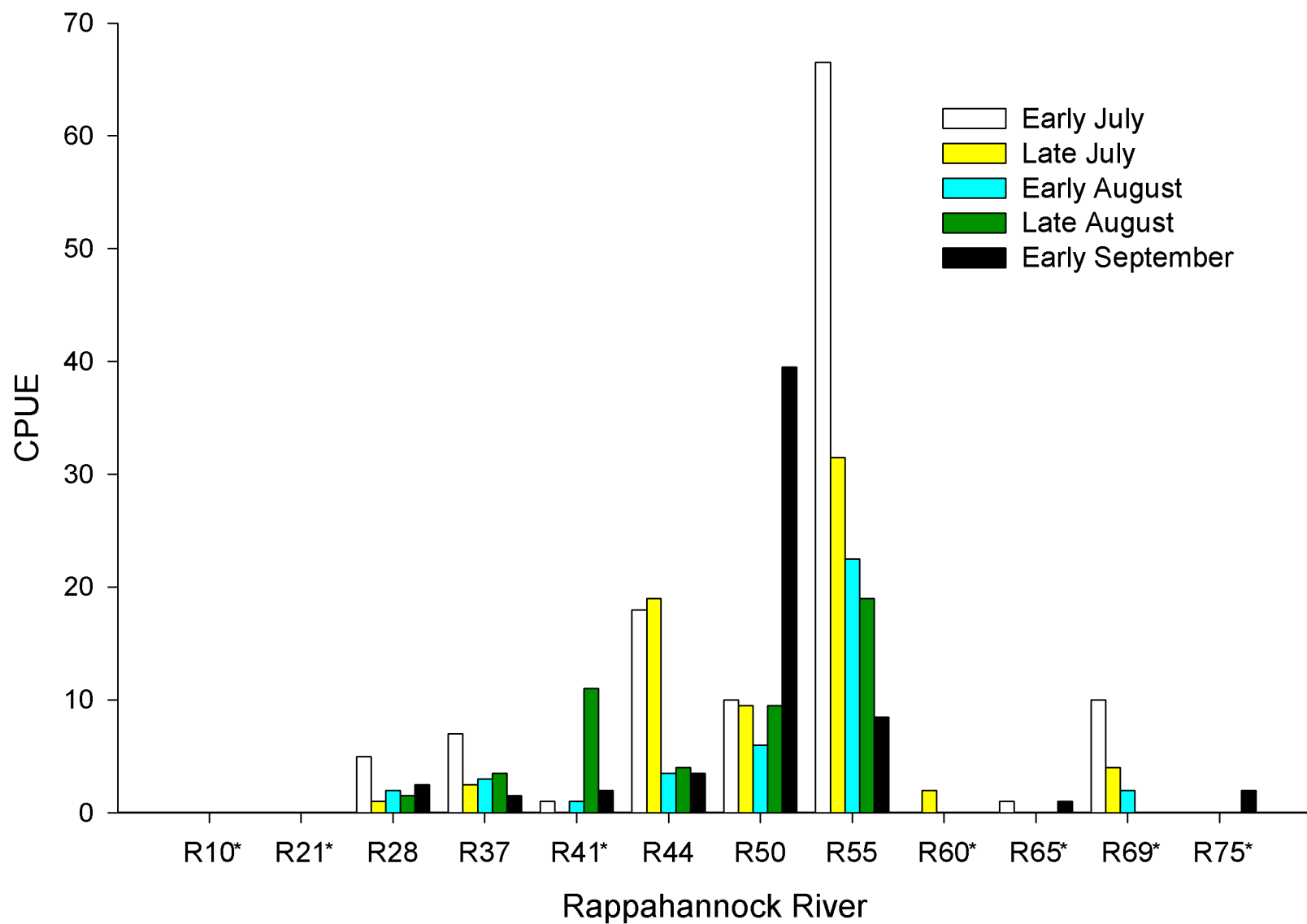


Figure 7. Catch of young-of-the-year striped bass by station in the Rappahannock River in 2006. Catch at index stations (non-starred) is an average of two hauls. Auxiliary station (starred) catch represents one haul.